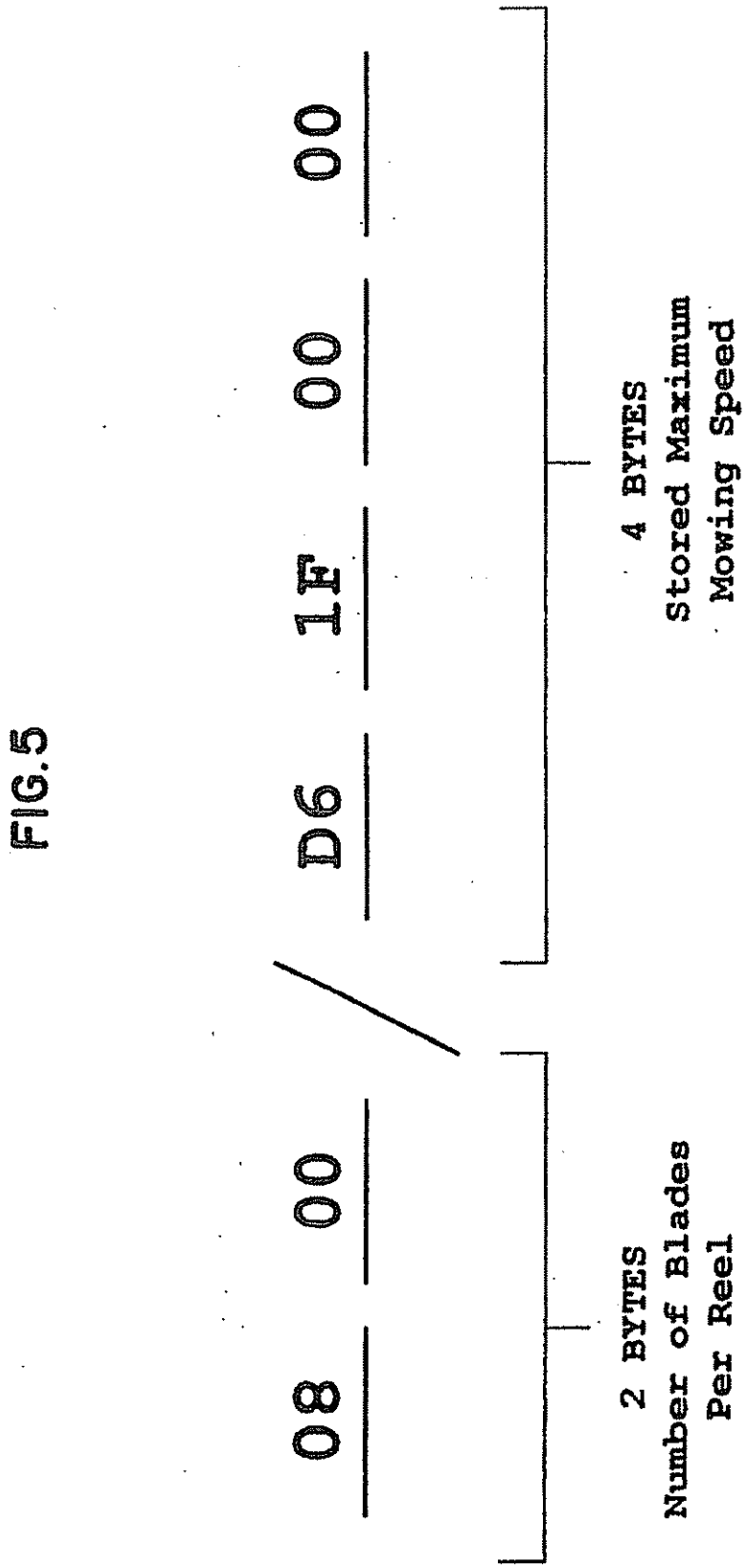
08
00
D6
1F
00
00
2 BYTES
Number of Blades
Per Reel
4 BYTES
Stored Maximum
Mowing Speed

FIG.5

SUPERVISOR SWITCH FOR TURF MOWER

FIELD OF THE INVENTION

The present invention relates generally to turf mowers, more particularly to a turf mower switch system for disabling the cutting units of the turf mower if the ground speed of the turf mower exceeds a predetermined speed and/or is less than a predetermined speed, and most particularly to a supervisor switch system for disabling the cutting reels of a reel type turf mower when the ground speed of the turf mower exceeds a predetermined speed.

BACKGROUND OF THE INVENTION

Rotary mowers and reel mowers are the two general types of turf mowers. Rotary mowers are generally used in high volume cutting environments and provide a rough cutting of the turf. When a more precise, finished cut is required, generally reel mowers are utilized. While the present invention relates primarily to reel mowers, those skilled in the art will recognize that the present invention may be useful in other styles of mowers as well. Therefore, while the preferred embodiment and examples will focus on reel mowers, the present invention should not be construed as so limited.

In a reel mower, there are one or more reels which rotate about a horizontal axis. The reel(s) operates in conjunction with a relatively stationary bedknife to shear off the grass blades. Generally, to maintain consistent quality of cut and to optimize the "clip" of the cut turf, the reel should be rotated more quickly with increasing ground speed. As used herein, the rotation of the reel will be referred to "reel speed." For a more detailed description of controlling reel speed in response to ground speed and to optimize the clip of the cut turf, reference may be had to the commonly assigned application titled *Electronic Control for Turf Maintenance Vehicle*, filed Jan. 3, 1992 (U.S. application Ser. No. 07/816,816) which is hereby incorporated herein by reference.

Typically, commercial reel mowers may be operated at certain top end or maximum ground speeds during transport (reels up). In the course of mowing, transporting the mower between areas to be cut, etc, operators need to have the maximum amount of control over ground speed. On the other hand, if the ground speed is too fast during mowing operations, the "clip" can become excessive (i.e., it degrades) and the cut turf can take on a poor appearance. That is, typically commercial turf mowers are designed so that they can travel at a ground speed greater than the preferred maximum mowing speed.

Therefore, supervisors prefer that operators mow at a ground speed less than the maximum possible speed of the mower. Also, the preferred mowing speed depends on the skill and experience level of the operator. For example, an experienced operator would know precisely when to raise and lower the cutting reel at the edge of a fairway when doing cross cutting, and therefore the more experienced operator may be capable of mowing at a faster ground speed. In fact, a supervisor might even want to establish a maximum mowing speed which is lower than the maximum "quality" mowing speed (i.e. the maximum speed possible while still maintaining an acceptable "clip").

It is a common perception, however, that slower mowing improves the final appearance of the turf. As noted in the Lonn et al application referenced above, there is generally a relationship between reel speed and ground speed which provides for optimized clip. Further, the luxury of cutting the turf slowly is usually not available since large amounts of turf are generally required to be cut in the least amount of time possible (in order to reduce the cost of maintaining the turf and maximizing play, among other factors) and to maximize the time that other activities can utilize the turf being maintained.

Accordingly, the maximum mowing speed at which a mower can travel while maintaining acceptable performance is important to establish. At speeds above the maximum mowing speed the cut turf takes on a poor appearance (e.g., the proper reel speed may not be possible and so the clip degrades), the speed may cause improper operation of the cutting units themselves (e.g., such as by bouncing over rough terrain), and the speed may cause a greater wear on the mower itself leading to more frequent mechanical breakdowns.

The prior art includes simple supervisor lock outs on vehicles. Such "lock outs" simply establish a maximum ground speed achievable by the vehicle. For example, some vehicles will lock out certain gears of a transmission (e.g., the top gear) by use of a keyed switch. Of course, there are also simple engine governors which limit the RPMs of an engine, thereby limiting the ground speed of a vehicle. However, each of these devices suffers from the drawback that maximum control and speed of the vehicle is altered.

Therefore, there is a need for a supervisor switch which does not affect the maximum ground speed of the mower. Further, such supervisor switch should establish a maximum mowing speed of the mower by disabling the reels if and when an operator exceeds a certain preselected ground speed.

SUMMARY OF THE INVENTION

The present invention provides for an automated supervisor switch device for maintaining a maximum ground speed during cutting operations. This speed will be referred to herein as the "maximum mowing speed." The present invention maintains the maximum mowing speed by disabling the cutting units if the speed is exceeded. Therefore, if an operator mows at speeds exceeding the predetermined maximum mowing speed, then the cutting units will be disengaged and the operator will be forced to repeat a mowing operation over the area in which the cutting units were disabled. This will tend to frustrate operators from exceeding the maximum mowing speed and promote mowing below the maximum mowing speed.

The present invention does not interfere with the maximum ground speed of the vehicle during non-cutting operations. For example, during transport, preferably the supervisor switch of the present invention is not operative. It is also contemplated that the present invention may provide for maintaining a minimum ground speed, either in addition to the maximum ground speed or in lieu of the maximum ground speed.

In a preferred embodiment of a device constructed according to the principles of the present invention, there is a controller apparatus located onboard a turf maintenance vehicle which monitors the ground speed of the vehicle and the enables of the cutting elements. However, those skilled in the art will appreciate that various other operative parameters of the vehicle may also be monitored by the controller apparatus.

First, a memory location is loaded with a predetermined maximum mowing speed. Second, the controller monitors the ground speed of the mower. Third, when the controller

determines that the cutting reels are operative and the ground speed is approaching the maximum mowing speed of the mower, then an audio and/or visual warning is actuated to alert the operator. Fourth, if the speed exceeds the predetermined maximum mowing speed, then the controller disables the reels from mowing. In the preferred embodiment, the controller disables the reels by shutting off the hydraulic fluid flow from the hydraulic motors which rotate the cutting reels. Fifth, the operator is forced to take certain corrective action to re-enable the cutting reels. In the preferred embodiment, the operator is forced to move the cutting reel engagement lever to its off and on positions.

One feature of the present invention, is that it may be implemented in software in a manner which allows a supervisor to optionally utilize the supervisor switch by using a remote computer to program a maximum mowing speed. An advantage of the present invention is that it improves performance of the mower in regard to clip, and also improves durability of the mower.

According to one aspect of the invention, there is provided: an improved turf mower comprising: (a) a vehicle including means for determining the ground speed of the vehicle; (b) a cutting unit supported by the vehicle, the cutting unit including a movable cutting element; (c) motor means for rotating the cutting element; and (d) control means operatively coupled to the speed determining means and the motor means for establishing a preselected maximum mowing speed, wherein if the vehicle ground speed, as determined by the ground speed determining means, exceeds the preselected maximum mowing speed, then the motor means is not energized by the control means or is de-energized by the control means if the motor means was previously energized, whereby the rotating cutting element is stopped from rotating.

According to another aspect of the invention, there is provided: a method for controlling the mowing speed of a turf mower having a cutting element, comprising the steps of: a) determining an unacceptable mowing speed for the turf mower; b) determining the ground speed of the turf mower and providing a sensed ground speed signal to a controller device; c) comparing the sensed ground speed signal to the unacceptable mowing speed; and d) de-energizing the cutting element of the turf mower if the sensed ground speed signal is determined to be unacceptable.

These and other advantages and features which characterize the present invention are pointed out with particularity in the claims annexed hereto and forming a further part hereof. However, for a better understanding of the invention, the advantages and objects obtained by its use, reference should be made to the drawing which forms a further part hereof, and to the accompanying descriptive matter, in which there is illustrated and described a preferred embodiment of the present invention.

BRIEF DESCRIPTION OF THE DRAWING

In the Drawing, wherein like reference numerals and letters indicate corresponding elements throughout the several views:

FIG. **1** is a perspective view of a commercial reel mower **10** in which environment a preferred embodiment of the present invention may reside;

FIG. **2** is a block diagram illustrating the hydraulic fluid system of the mower **10** of FIG. **1**;

FIG. **3** is a diagrammatic block diagram illustrating the relationship between the mechanical and electronic components of a device constructed according to the principles of the present invention;

FIG. **4** is a logic flow diagram for the programming steps utilized by the controller **100** of FIG. **3** which implements the supervisor switch functions; and

FIG. **5** is a diagrammatic illustration of a memory location which stores the data related to the maximum mowing speed.

DETAILED DESCRIPTION OF THE INVENTION

The principles of this invention apply to the monitoring and active modification of the enablement and disablement of an operative system of a vehicle. The apparatus and method includes the updating and control of the operative system in accordance with predetermined criteria to achieve a desired maximum ground speed (and/or a minimum ground speed) during the performance of that operation. A preferred application for this invention is in the monitoring and control of the maximum mowing speed in a turf maintenance vehicle.

Although the example of mowing a golf course will be utilized herein, those skilled in the art will appreciate that such application is only one of many mowing type environments in which the principles of the present application might be utilized. Accordingly, the golf examples presented herein should not be construed in a limiting manner. Also, those skilled in the art will appreciate that although the present control device is illustrated in the drawing as residing on a particular turf mower having a predefined number of reels and blades per reel, it should be understood that any number of reels and blades per reel can be controlled by the present invention, as well as other styles of mowers and mulchers.

In order to better present and describe the preferred embodiment of the present invention, the detailed description of the supervisor switch apparatus and method will be deferred pending a discussion of a preferred embodiment turf mower on which the present invention might be used.

Referring first to FIG. **1**, there is shown a typical commercial riding reel mower **10** with which the present invention may be used. As noted above, such mowers are typically utilized for cutting large areas such as golf courses, football fields, parks and the like. The mower **10** includes a rear housing **12** enclosing an engine compartment **14** which is hydraulically coupled via a transmission (best seen in FIG. **2**) to a pair of front driving or traction wheels **16**. The operator sits in a seat **18** positioned in front of the engine housing **12** and controls operation of the mower **10** by means of hand controls **20**, foot controls **22***a*, **22***b* and a steering wheel **24** which is cooperatively connected to a pair of rear steering wheels **26**, only one of which is shown. The rear steering wheels **26** are of relatively smaller diameter and tread than the front traction wheels **16**, for purposes of better maneuverability.

Still referring to FIG. **1**, the mower **10** includes a frame having a projecting forward platform on which the foot controls **22***a*, **22***b* and pedestal for steering wheel **24** are mounted. A front lift arm assembly **30** is mounted on the front end of frame **28** between the front wheels **16**, while a rear lift arm assembly **32** is mounted on the frame between the front wheels and the rear wheels **26**. As will be explained more fully below, the lift arm assemblies **30** and **32** include lightweight cutting reels mounted on pivotal lift arms that are normally biased by adjustable spring assemblies down-

wardly into contact with the turf. Hydraulic cylinders operate to raise and lower the lift arms between their extreme positions. The operation of the lift arm assemblies is discussed-more fully in U.S. Pat. No. 5,042,236, which is hereby incorporated herein by reference.

Cutting reels are mounted on the outer end of each of the lift arms of the front lift arm assembly **30**. More particularly, cutting reel **48** is secured to the outer end of the right outboard lift arm **58**, cutting reel **50** is secured to the outer end of the middle lift arm **60**, and cutting reel **52** is mounted on the outer end of the left outboard lift arm **62**. Each of the cutting reels **48**, **50** and **52** is of substantially conventional construction, including hydraulically driven transverse blades positioned between front and rear transverse rollers. Such cutting reels **48**, **50** and **52** are usually enclosed by grass shields and baskets, only two of which shields/baskets **54** and **56** are shown in FIG. **1** for the purposes of clarity. As noted above, each of the cutting reels move past a bedknife **113** (best seen in FIG. **3**). Hereinafter, the reels will be described by the designation **48** for clarity.

The mower also includes a rear lift arm assembly **32** which is mounted on the lower frame **28** between the front wheels **16** and the rear wheels **26**. The rear lift arm assembly **32** includes two lift arms (not shown) which are supported and biased downwardly by hydraulic actuators and adjustable spring assemblies respectively similar to those in front lift arm assembly **30**.

Moving now to FIG. **2**, there is illustrated the preferred hydraulic system **80**. The hydraulic system **80** is energized by prime mover **81** which is cooperatively connected via drive shaft **82***a* to reel hydraulic pump **83***a* and via drive shaft **82***b* to transmission hydraulic pump **83***b*. Transmission hydraulic pump **83***b* is in turn connected to differential **85** via shaft **84**. As those skilled in the art will appreciate, the differential **85** drives the wheels **16** in response to commands from an operator via the foot control **22***a*. Reel hydraulic pump **83***a* is connected to manifold **86** via input and output lines **87**, **88** respectively and includes a hydraulic fluid reservoir tank. In the preferred embodiment, hydraulic reel pump **83***a* may be manufactured by Webster Fluid Power Products, Inc. of Easley, S.C., under the model designation 49913-6.

The manifold **86** includes connections for various devices and apparatus driven by hydraulics on the mower **10** including lifting the reels on the front lift arm assembly **30** and rear lift arm assembly **32**. The hydraulic connections are illustrated with greater clarity in the Lonn et al application, incorporated by reference above.

The reels are driven hydraulically via hydraulic motors **71** through **75**. In the preferred embodiment, the hydraulic motors may be of the type manufactured by Webster Fluid Power Products, Inc. of Easley, S.C., under the model designation 152-10000353 and are preferably of the constant displacement type. The motors **71–75** are cooperatively connected to the reels in a well known manner such that when hydraulic fluid passes through the reel motors **71–75**, the reels **48** rotate.

Still referring to FIG. **2**, controller **100** (discussed in more detail below and best seen in FIG. **3**) is cooperatively connected to the manifold **86** via line **101** to operate various valves within manifold **86**. The valves (best seen diagrammatically in FIG. **3**) control the hydraulic fluid flow to hydraulic motors **71–75**. A more detailed discussion of the hydraulic fluid flow and operation of the valves is provided in the Lonn et al application, incorporated by reference above.

Referring to FIG. **3**, certain inputs are provided to the controller **100**. The controller **100** receives input signals from input block **103** which includes proper buffers, A/D devices, etc. The input signals are originally generated by encoder devices, such as optical encoders, Hall effect devices, etc. Accordingly, reel-speed and ground-speed are determined and provided to controller **100**.

The process of determining the number of revolutions of transmission gear teeth and locating pickups on rotating objects such as the transmission gear **85***a* and reels **48** via optical encoders, Hall Effect devices, etc. is well known in the art and so will not be described in detail herein. Preferably Hall effect devices are used to determine the ground speed and reel speed although any number of other type devices may be used as will be appreciated.

In the preferred embodiment, the actual ground speed is determined by an interrupt driven input. More specifically, the Hall effect sensor **104** provides a signal for each passage of a gear tooth past the sensor. Each time that eight gear teeth pass the sensor **104**, then an interrupt occurs in the input block **103** which provides the microprocessor **102** with a time period corresponding to the time required for eight transmission gear teeth to move past the sensor **104**. Since the distance that the mower **10** moves is known for each fraction of revolution of the transmission gear **85***a* and the time is known (since the period is known), then the rate of speed may be calculated.

It will be appreciated by those skilled in the art that the speed measured by the Hall effect sensor **104** may vary slightly from the "actual ground speed" of the mower **10** due to tolerance variations in the differential **85** and slipping of the wheels **16** (if any), among other factors. While radar and laser systems, etc. might be used to determine a more precise actual ground speed, it is thought that the results from the Hall effect sensor **104** measurement provide an accuracy which is acceptable. Accordingly, the measured speed is referred to herein as the "actual ground speed."

RS-232 interface block **105** provides a two-way communication port to microprocessor **102** for diagnostics, testing, and for loading the maximum mowing speed. Thus, a remote computer **106** may be utilized to provide field-loaded software instructions to reside in non-volatile memory block **107** and to implement and/or change the predetermined maximum cutting speed.

In the preferred embodiment, the microprocessor **102** may be of the type manufactured by Intel having a model designation 80C196KB. The microprocessor **102** is preferably a 16 bit microcontroller. Included with microprocessor **102** is nonvolatile memory block **107** and random access memory block **108**. Controller **100** is comprised of blocks **102**, **103**, **105**, **107**, **108**, and **111**.

Output is provided to an operator perceptible indicia device **110**, such as an out of range lamp preferably located in a position easily visible to an operator in order to notify the operator of a fault condition in the clip control and/or to warn the operator that the maximum mowing speed is being approached and/or exceeded. Those skilled in the art will appreciate that buzzers, horns, vibration devices, etc. might also be used in addition to or separately from the preferred out of range lamp illustrated in FIG. **3**. It will also be appreciated that reverse logic might be used in activating the operator perceptible indicia such that the light, horn, etc. could be turned "off," rather than being turned "on" when a condition occurs. Therefore, while the operator perceptible indicia is discussed herein as being energized, those skilled in the art will appreciate that negative logic (to turn the indicia off) is to be included in such language.

Output devices block **111** preferably includes several high speed pulse width modulated drivers for controlling the reel speed in a manner related to the measured ground speed during mowing operations in order to optimize the clip. The output from the output drives **111** is also used to enable the reels **48** if the maximum mowing speed is not exceeded. The controller **100** preferably utilizes a feedback control loop to maintain the actual reel speed at a target speed. The feedback control loop is described in more detail in the Lonn et al application, incorporated by reference above.

While not specifically detailed in FIG. **3**, it will be understood that the controller **100** includes various logic gates, flip-flops, etc., and must be properly connected to appropriate bias and reference supplies so as to operate in its intended manner. Similarly, it will be understood that appropriate memory, clock oscillator, buffer and other attendant peripheral devices are to be properly connected to controller **100** so as to operate in its intended manner.

Having now described in detail the hydraulic operation of the reels and the interconnection of the electronic controller **100**, a discussion will now be presented describing the logic flow of the microprocessor **102** of controller **100** in carrying out the supervisor switch apparatus and method. In a preferred embodiment of a device constructed according to the principles of the present invention, the logic means comprises a microprocessor **102** which sequentially polls the inputs, including the asynchronous interrupts. A logic flow diagram of an embodiment of the program logic which might be resident in the microprocessor **102** or stored in nonvolatile memory block **107** or RAM **108** is illustrated in FIG. **4**, wherein the logic diagrams is shown generally at **200**. The logic flow diagram **200** generally illustrates the steps taken to analyze the logical status of the various inputs and provide outputs to enable/disable the reels **48**.

Although the microprocessor **102** will be characterized as "proceeding" from logical block to logical block, while describing the operation of the program logic, those skilled in the art will appreciate that programming steps are being acted on by microprocessor **102**.

In the preferred embodiment, a maximum mowing speed is provided to the controller **100**. Preferably, this information is input by means of a separate/remote PC **106** which is connected by means of a serial cable to an RS-232 port **105** of the controller **100** which resides on the turf mower **10**. The controller **100** preferably stores the maximum mowing speed in its EEPROM type non-volatile memory **107**.

In the preferred embodiment, the remote PC **106** performs the calculations necessary for the desired maximum mowing speed. For example, since the processor **102** is measuring a period of time per number of pulses from gear teeth passing a sensor **104** (as described above), a speed entered by an operator must be transformed into a period. For example, if six (6) miles per hour were the maximum mowing speed, then the remote PC would calculate the period between eight (8) gear teeth which is 0.0163 second (as described above). This number can be converted into an integer number of 1850 (this number will correspond to the timer count for the interrupt and, for example, preferably assumes 2 microseconds per timer count). This number can then be converted into a hexadecimal number 1FDG for storage in the six byte memory location illustrated in FIG. **5**. The first two bytes of the memory location are used for storing the number of blades on the reel, in hexadecimal. The leftmost byte as shown in FIG. **5** is the least significant byte in accordance with the preferred embodiment memory storage methodology.

Alternately, the controller **100** may automatically determine the maximum mowing speed by means of a switch or by calculating the number. The number of blades per reel may be used by the controller **100** for automatically determining the maximum mowing speed, along with other variables (e.g., height of cut).

Turning now to FIG. **4**, first, at 200 there is illustrated a main controller program loop which begins at block **201**. Proceeding to block **202**, the controller **100** determines the proper pulse width modulated signals to control the reel speed relative to the ground speed (as more fully discussed in Lonn et al, incorporated by reference above). The determined output is not yet provided by processor **102** to block **111** and thus, the reels are not yet enabled. Next at block **203** the processor **102** determines if a maximum mowing speed has been set in memory **107** as discussed above. Since the default value is preferably all logical ones, the processor **102** need only perform a logical compare with a hexadecimal FFFF to determine if a maximum mowing speed has been set. If a maximum mowing speed has been set, then the program sets two flags after the compare operation at block **204**. A first flag is set if the actual ground speed is greater than a predetermined fraction of the maximum mowing speed (in the preferred embodiment ⅞). A second flag is set if the actual ground speed is greater than the set maximum mowing speed (shown in FIG. **4** as equalling 1 times the maximum mowing speed).

If a mowing speed has not been set, then the program proceeds to block **214** where the outputs are provided to device **111**. From block **214**, if the mower **10** is to be shut off, the processor ends at block **215**. Otherwise the processor **102** proceeds to block **202** to continue the main program loop.

The maximum mowing speed subroutine continues at block **205**, after Flag **1** and Flag **2** are properly set, by checking a logic table to determine if the reels **48** should be engaged. Flag **2** is used as one condition which must be met prior to enabling the reels **48** or keeping the reels **48** enabled (i.e., if the maximum mowing speed has been set and Flag **2** has been set, then the logic table indicates that the reels **48** should not be operative/enabled).

Proceeding to block **206**, the processor **102** determines whether the operator has re-requested mowing or has disabled mowing. Whether the operator has requested mowing or has disabled mowing is determined by controller **100** via the engagement of joystick **109** (generally seen in FIG. **1** as one of the hand controls **20**) and the sensor **112**. As noted above, once the reels **48** are disabled, the operator must positively move the joystick **109** in order to reenable the reels **48**. However, the operator may alternately determine that mowing should be disabled. As noted above, the supervisor switch device does not operate if mowing is not requested. Therefore, if the operator has re-requested mow or has disabled mow, then the processor **102** proceeds to block **207** to unlatch Flag **3**.

If the operator has not re-requested mow or disabled mow, the processor **102** proceeds to block **208** where it determines if mow is requested and Flag **2** is set (i.e., is the maximum cutting speed being exceeded while mow is requested). If yes, the processor **102** proceeds to block **209** where Flag **3** is latched and thereafter to block **210** where the pulse width modulated signal is modified. It will be understood that Flag **3** may have been previously latched and so block **209** may not change the status of Flag **3**.

As will be appreciated by those skilled in the art, the signal is to be sent to the manifold **86** and appropriate valves

later in the logical flow (the outputs are preferably sent at block **214**). Further, while the signal may be considered to be "turned off" or modified to zero, it will be appreciated that various logical schemes may be utilized and that the desired function is to interrupt the hydraulic fluid flow from the manifold **86** to the hydraulic motors **71–75**. In this manner, reels **48** are disabled or kept from becoming enabled. It will be further appreciated that as used herein, the language regarding de-energizing or disabling the reels also includes not originally energizing or enabling the reels in those instances that the maximum cutting speed is being exceeded prior to the operator requesting a mowing operation.

If mow has not been requested and Flag **2** set, then the processor **102** continues to block **211** where if Flag **1** is set, then the out of range lamp **110** is flashed slowly. Continuing to block **212**, if Flag **3** is set, then the out of range lamp is flashed quickly. It will be appreciated that if Flag **3** is set, then the instruction to flash quickly will override the setting to flash slowly at block **211**.

Proceeding to block **213**, Flag **1** and Flag **2** are cleared and the outputs are sent at block **214**. As discussed below, if the mower **10** is to be turned off, the processor **102** continues to block **215**, otherwise it proceeds to block **202** to continue the program loop.

It will be appreciated that the processor compares a fraction of the stored maximum mowing speed with the actual speed at block **204**. In the preferred embodiment, the fraction is ⅞, however, any fraction which provides an indication to the operator that the maximum mowing speed is being approached might be used. If the actual speed exceeds the fractional maximum mowing speed then the processor **102** begins to flash the out-of-range light **110** slowly. In the preferred embodiment, the "out of range" light is located on the control panel and may flash at a rate of 1/10 of a second on and 9/10 of a second off, although a wide variety of actual rates might be used.

At block **212**, if the actual ground speed exceeds the maximum mowing speed preselected by the supervisor, the out of range light **110** starts to flash rapidly (e.g., 1/10 of a second on, 1/10 of a second off, etc., etc.). The reel(s) **48** is/are de-energized to actually prevent the operator from mowing at this speed. The mower is "latched" into this state until the operator re-enables the reels **48** by positively moving the joy stick **109** on the control panel of the mower **10**, however the ground speed is not affected. The reels are re-energized only if the mowing speed drops below the maximum mowing speed. It will be appreciated that the reels **48** may be deactivated by sending the proper pulse width signal to block **111** (or no pulse width signal), depending upon the scheme used by the valves in manifold block **86**.

It will be appreciated by those skilled in the art that although the present invention has been illustrated with a software-based control system, it may also be implemented with discrete electrical components. Similarly the apparatus could be implemented mechanically (e.g., with a governor device actuating a switch to cut off the motors), hydraulically (e.g., by pumping oil across an orifice to generate a flow rate signal which pops a pressure relief valve), or hard-wire electronically or electrically. Additionally, while the preferred embodiment determines whether the operator has requested a mowing operation or re-requested a mowing operation, and senses the status of the mowing operation by determining the position of the joystick **109**, the present invention might also be implemented by merely comparing the actual ground speed against a predetermined speed or range.

Further, it is to be understood that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only and changes may be made in detail, especially in the reel drive system. For example with regard to the latter, variable displacement or electric motors might be used. Further, although reels which include a certain number of blades are presented herein for purposes of illustration, other configurations might be used. Also, the invention may also provide for a minimum ground speed either in addition to or in lieu of the maximum. Other modifications and alterations are well within the knowledge of those skilled in the art and are to be included within the broad scope of the appended claims.

I claim:

1. An improved turf mower comprising:

(a) a vehicle including means for determining the ground speed of the vehicle;

(b) a cutting unit supported by the vehicle, the cutting unit including a movable cutting element;

(c) motor means for rotating the cutting element; and

(d) control means operatively coupled to the speed determining means and the motor means for establishing a preselected maximum mowing speed, wherein if the vehicle ground speed, as determined by the ground speed determining means, exceeds the preselected maximum mowing speed, then the motor means is not energized by the control means or is de-energized by the control means if the motor means was previously energized, whereby the rotating cutting element is stopped from rotating.

2. The mower of claim **1**, wherein the motor means is a hydraulic motor.

3. The mower of claim **1**, wherein the control means is an electronic controller including a microprocessor.

4. The mower of claim **1**, wherein the cutting unit is a reel blade which rotates about a longitudinal axis past a relatively stationary bedknife.

5. The mower of claim **1**, further comprising operator perceptible indicia, wherein the control means is operatively connected to the operator perceptible indicia for alerting the operator when the preselected maximum mowing speed is being approached or exceeded.

6. An improved turf mower comprising:

(a) a vehicle including means for determining the ground speed of the vehicle;

(b) a cutting unit supported by the vehicle, the cutting unit including a movable cutting element;

(c) motor means for rotating the cutting element;

(d) control means operatively coupled to the speed determining means and the motor means for establishing a preselected maximum mowing speed, wherein if the vehicle speed, as determined by the ground speed determining means, exceeds the preselected maximum mowing speed, then the motor means is not energized by the control means or is de-energized by the control means if the motor means was previously energized, whereby the rotating cutting element is stopped from rotating; and

(e) reset means, operatively connected to the control means, for providing a reset signal to the control means, wherein if the vehicle ground speed is less than the preselected maximum mowing speed when the reset means are activated, then the control means re-energizes the motor means.

7. The mower of claim 6, wherein the reset means is a joystick actuated by an operator of the mower.

8. The mower of claim 1, wherein:

a) the motor means is a hydraulic motor;

b) the control means is an electronic controller including a microprocessor; and

c) the cutting unit is a reel blade which rotates about a longitudinal axis past a relatively stationary bedknife.

9. The mower of claim 8, further comprising operator perceptible indicia, wherein the control means is operatively connected to the operator perceptible indicia for alerting the operator when the preselected maximum mowing speed is being approached or exceeded.

10. The mower of claim 8, further comprising reset means, operatively connected to the control means, for providing a reset signal to the control means, wherein if the vehicle ground speed is less than the preselected maximum mowing speed when the reset means are activated, then the control means re-energizes the motor means.

11. The mower of claim 10, wherein the reset means is a joystick actuated by an operator of the mower.

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(54) **Moving tractor with towed mower.**

(57) The towed mower (22) is attached by a hitch (44) to the self propelled front mower (21). The front mower has its own forwardly positioned cutter unit (30). The towed mower has a centrally positioned frame segment (62) that does not include a cutting blade, and the two side frame segments (63) and (64) each include cutting blades that are supported in bat-wing fashion from the central frame segment. The swath cut in the grass by the front mower 21 is straddled by the swaths cut by the blades of the side frame segments (63) and (64) of the towed mower (22).

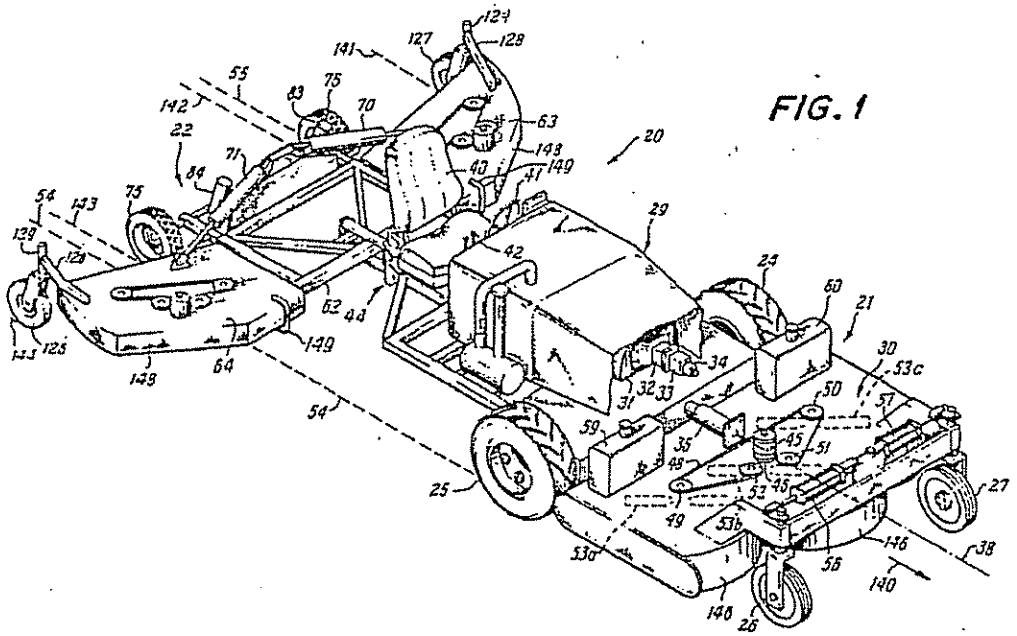

FIG. 1

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MOWING TRACTOR WITH TOWED MOWER

FIELD OF THE INVENTION

The invention disclosed herein relates to a self propelled riding mowing tractor or mowing machine of the type adapted for cutting grass and other vegetation, and includes a towed mower which can be detachably mounted to the front self propelled mowing tractor in trailer fashion, and the towed mower can be attached to and work in combination with the front mowing tractor for cutting over relatively flat, wide terrain, with the mowing tractor cutting a central swath in the grass and the towed motor cutting outer swaths in the grass that straddle the central swath.

DESCRIPTION OF THE PRIOR ART

Self propelled riding mowers are commonly used for the purpose of cutting grass and other vegetation and the mowers have been constructed in several different design categories. Mowers are commonly used for the purpose of cutting grass and other vegetation for agricultural and ornamental purposes. Mowers are constructed in different categories such as walk behind, riding, and remote controlled. Mowers are pushed, pulled, self propelled and self powered, or are powered and propelled by tractors or other accommodating units. The cutters on mowers consist of one or more cutting devices, such as rotary blades, reel cutters, flail cutters and sickle bar cutters, which are grouped into cutter assemblies. Several cutter assemblies may be used on one mowing machine.

For example, the prior art mower designs include the conventional high standing farm style tractor, garden tractor or mowing machine having cutter elements mounted beneath the belly of the tractor, behind the steerable front wheels and in front of the rear powered wheels.

Another prior art mower assembly includes the conventional farm style tractor and a towed mower assembly pulled behind the tractor, with the power take off system of the tractor functioning to power the cutter elements of the towed mower. In some instances, the towed mower includes a central, forwardly positioned rotary cutting blade and slide blades positioned out to the side and slightly behind the forward blade, with a central gear box that is driven by the power take off the tractor, and with driving shafts extending from the central gear box to the side cutting blades. In some models the cutting blades are driven by hydraulic motors, with the tractor having a pump that operates the hydraulic motors. The individual side cutter assemblies on this style of mower usually can be tilted to cut at different heights or to reduce the width of the unit for better handling, particularly when the mower is in transit on a public road. When the side cutter blades are raised with respect to the center cutter blade, the center cutter blade does not have shields that prevent objects from being thrown to the side. Therefore the mower is unsafe to operate with side uctter blades raised.

Another type of prior art mower comprises a tractor or self propelled mower provided with cutter assemblies that are positioned out in front of the tractor, or under its belly, and some include both front and side mounted cutter assemblies to broaden the swath cut by the assembly. These side cutter attachments normally follow the contour of the ground but may be raised and lowered to cut over objects or to facilitate transit.

Another type prior art mower configuration used for slope mowing is the type generally illustrated in U.S. Patent 4,700,536 and comprises a low profile slope mower which includes a power unit having rear driving wheels and a forwardly positioned cutter unit which supports the cutter blades. The low profile of this unit together with the relatively high engine power and good maneuverability of the unit makes the unit stable when cutting on sloped surfaces, such as along the embankments of interstate highways, golf course embankments, ditch banks, ski slopes and other finish, refined or roughly vegetated sloped terrains.

However, none of the prior art mowers known to the inventor have successfully included a front self propelled riding mower tractor with its own cutter and a rear trailing towed mower connected to the front tractor by a central pivoting hitch, with side cutters that straddle and broaden the swath cut in the grass by the front mower and which can be tilted upwardly. It is to this arrangement of mower elements that this invention is directed.

SUMMARY OF THE INVENTION

Briefly described, the present invention comprises a front cutting or belly cutting self propelled riding mowing tractor or mowing machine, with a rear towed mower, whereby the towed mower is pulled along in trailer fashion behind the forwardly positioned self propelled mowing tractor. The front self propelled mowing tractor or mowing machine, referred to sometimes herein as the "front mower", includes its own cutting unit with an engine that is used to power its driving wheels as well as its front or belly mounted mower. A trailer connecting device is mounted between the front mower and the towed mower so that the towed mower is connected to and follows the front mower in trailer fashion.

The towed mower has three frame segments. The central frame segment includes ground engaging support wheels, a portion of the connecting device to the front mower and hinge means for the two side frame segments. The side frame segments each includes at least one cutter and a supporting wheel member. The cutters of the towed mower assembly preferably are powered by the engine of the front mower; however, the towed mower can be constructed with its own independent source of power to its cutters. The noncutting central frame segment of the towed mower is positioned so as to ride over the swath previously cut by the cutter unit of the front self propelled mower, whereas the side segments of the towed mower are positioned so that their cutters cut swaths that straddle and intersect the central swath, resulting in the formation of one wide uninterrupted cut.

The prior art towed mowers of the type having a center cutter and hinged side cutters typically have the cutters arranged in a longitudinally staggered, overlapped relationship so as to avoid leaving streaks of uncut grass. Because of this requirement these cutter assemblies are long in relation to their width. However, the towed mower of this invention has its central frame segment constructed without a cutter. Therefore the cutters of the side frame segments of the towed mower do not have to be offset longitudinally with respect to a central cutter and the length of the towed mower of this invention is shortened by the absence of the usual central cutter. Moreover, the overall length of the combined self propelled front mower and towed mower is shortened. Further, the distance between the supporting wheels of the towed mower and the rear driving wheels of the forwardly positioned self propelled mower is minimized by the short configuration of the towed mower. This configuration results in the towed mower closely following the swath cut by the forwardly positioned cutter of the self propelled mower when the self propelled mower and towed mower are driven through a turn, as well as when trailing over undulating turf. When the two cutter units are raised vertically on the towed mower the width of the towed mower is less than the width of the front mower and the front mower can be used to trim close to and around objects since the nonfunctioning towed mower will trail within the cut swath of the front mower. This configuration provides the best trimming capability of the front mower as the rear mower does not engage an obstacle outside the path of the front mower.

Optionally, the trailer connecting device that connects the towed mower in trailer fashion to the front mower can be made easily detachable, enabling the operator to quickly attach and detach the towed mower from the self propelled front mower, so that the operator can mow the broad, flat surfaces of an area with the combination of the self propelled front mower and the rear towed mower, and the operator can quickly detach the towed mower from the front mower and use the front mower separately to mow in confined areas, to perform slope mowing or to power or propel various attachments that can be mounted to the front mower.

Thus, it is an object of this invention to provide an improved self propelled front mower and towed mower combination, whereby the towed mower is towed behind the front mower in trailer fashion and the cutters of the towed mower straddle and broaden the cut swath formed by the cutters of the front mower.

Another object of this invention is to provide a towed mower that is adaptable for being towed behind a front self propelled mower, whereby the towed mower has laterally displaced side cutting elements which are arranged to straddle the swath cut by the forwardly positioned cutter unit of the self propelled mower, and includes a central frame segment that does not have a cutting element and rides over the swath cut by the forwardly positioned self propelled mower and which allows the towed mower to be relatively short in length and highly maneuverable.

Another object of this invention is to provide a towed mower for attachment to a front mower which has a central frame segment and vertically hinged side frame segments which can be raised to nonoperating vertical positions for transport and to facilitate trimming with the front mower and to avoid collision between the rear mower and obstacles being trimmed around.

Another object of this invention is to provide a self propelled mower with a detachable towed mower, with the front self propelled mower being of low center of gravity construction suitable for mowing on sloped surfaces, and with the rear towed mower comprising three frame segments which are tiltable with respect to

each other, with a central frame segment arranged to ride over the swath cut by the front self propelled mower and with the side frame segments supporting cutters that cut side swaths that straddle and broaden the central swath cut by the front mower.

Another object of this invention is to provide an improved, light weight towed mower that closely follows a front mower in centrally pivoted trailer fashion and which includes side cutters that straddle and broaden the swath cut by the front mower, and which skew to the side when propelled into objects that may have passed to the side of the front cutter so that damage to the towed cutter, dislocation of the front mower and damage to the object impacted are all reduced or substantially eliminated because of the angled arrangement of the cutters along with angled front edges of the housing and the relatively reduced weight and length of the towed mower due to the absence of a center cutting section.

Another object of this invention is to provide a self propelled front mower with a centrally pivoted detachable towed mower giving a combined wide cutting swath and a short turning radius due to the overall length of the towed mower being reduced by the absence of a center mowing section.

Another object of this invention is to provide a front self propelled mower and a rear towed mower combination with the towed mower having cutter sections that straddle the cut swath formed by the front mower and which can be tilted to upright inoperative positions as the front mower continues to operate and continues to form its cut swath.

Another object of the invention is to provide a self propelled front mower and a towed mower combination, with the towed mower having side cutters that straddle the swath cut by the front mower and which can be tilted upwardly to inoperative positions so that the width of the towed mower is less than the width of the front mower whereby the front mower can be used to trim about objects with the towed mower trailing directly in the cut swath of the front mower in a path that will not impact the objects trimmed around by the front mower.

Other objects, features and advantages of this invention will become apparent upon reading the following specification, when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective illustration of a mower assembly showing the front and right hand side of both the front self propelled mower and the rear towed mower.

Fig. 2 is a perspective illustration of the towed mower, showing the left hand side and rear of the towed mower.

Fig. 3 is a detail perspective of the trailer hitch connection between the front mower and towed mower.

Fig. 4 is a plan view of a second embodiment of the towed mower, with the mower having three cutters in each side segment.

Fig. 5 is a plan view of another embodiment of the towed mower, with the mower having a single cutter in each side segment.

Fig. 6 is a plan view of another embodiment of the towed mower with the mower having three cutters arranged in a staggered relationship in each side segment.

Fig. 7 is a plan view of another embodiment of the towed mower with the support wheels of the central segment being located beneath the central segment.

Figs. 8, 9, 10, and 11 are perspective illustrations of trailer hitch constructions which can be utilized to connect the towed mower to the front self propelled mower.

Fig. 12 is a plan view of the mower assembly of Fig. 1, and illustrating how the mower assembly performs when operating in a turn.

Fig. 13 is a schematic illustration of the mower assembly when in a turn, demonstrating how the proportions of the mower are calculated so as to provide a swath cut in the grass by both the front self-propelled mower and the rear towed mower without having streaks of uncut grass appear in swaths of cut grass.

DETAILED DESCRIPTION

Referring now in more detail to the drawings, in which like numerals indicate the like parts throughout

the several views, Fig. 1 illustrates the mower assembly 20 which includes a front self propelled riding mowing tractor 21 and a rear towed mower 22. The front self propelled mowing tractor 21, referred to as the "front mower", is illustrated as a slope mower of the type that has rear powered driving wheels 24 and 25, front steerable wheels 26 and 27, with the rear powered wheels 24 and 25 supporting a power unit 29 and the front steerable wheels supporting a cutter unit 30.

The power unit 29 or the front mower 21 includes an internal combustion engine 31 that operates a plurality of pumps 32, 33 and 34 which are mounted in series on the engine 31. Pump 32 is the wheel propulsion pump, pump 33 is the front deck drive pump, and pump 34 is the drive for auxiliary functions such as power steering and lift cylinders. Other pumps (not shown) are located behind and are driven by the engine which function as the towed mower drive pumps.

A pivot connection 36 functions to connect the cutter unit 30 to the power unit 29 so that the cutter unit 30 is pivotable about a longitudinal axis 38. The pumps 32-34 project from the internal combustion engine 31 over the pivot connection. With this arrangement, the cutter unit 30 can tilt with respect to the power unit 29 during the movement of the mower assembly over uneven terrain, and the pumps 32, 33 and 34 remain in a space above the cutter unit 30 without obstructing the tilting movements of the cutter unit with respect to the power unit.

The power unit 29 includes a driver's seat 40 that is located rearwardly of the driving wheels 24 and 25, with a steering wheel 41 and various throttle controls, pump controls and other controls 42 located in front of the driver's seat. A trailer tongue 44 projects from the power unit 29 adjacent the driving wheels 24 and 25 rearwardly beneath the driver's seat to the towed mower 22 and is connected to the towed mower.

The cutter unit 30 of the front mower 21 has a hydraulic motor 45 mounted to the decking of the cutter unit, and a drive sheave 46 mounted on top of the motor 45 engages the driving belt 48. The driving belt 48 extends to driven sheaves 49, 50 and 51 and the sheaves are each connected by means of a mandrel to a cutting blade beneath the decking of the cutter unit 30. A spring biased idler sheave 52 maintains proper tension in the driving belt 48. The rotary cutters 53a, 53b, 53c driven by the driving belt 48 are arranged in a triangular staggered relationship with respect to each other so as to cut a single swath in the grass beneath the cutting deck 21, as indicated by the dash lines 54 and 55.

The front self propelled mower 21 is steered by its front steerable wheels 26 and 27. Hydraulic cylinders 56 and 57 impart steering motion to the wheels 26 and 27, and the cylinder 56 and 57 are operating by a power steering pump 34, which is in turn controlled by the steering wheel 41 of the power unit 29. Fuel tanks 59 and 60 are mounted to the decking of the cutter unit 30 and supply fuel to the internal combustion engine 31.

As illustrated in Fig. 2, the rear towed mower 22 comprises a support frame 61 having a central segment 62 and side segments 63 and 64 located on opposite sides of the central segment 62. The side segments 63 an 64 are covered by sheet metal decking, with the decking forming part of the side segment support frame. The side segments 63 and 64 are tiltable with respect to the central segment by means of hinges 66, 67 and 68, 69. Hydraulic cylinders 70 and 71 are each connected between a central frame element 72 on the central segment 62 and to stanchions 73, 74 mounted to the side segments 63, 64. When the cylinders 70 and 71 are retracted, the side segments 63 and 64 are tilted up to a vertical attitude suitable for highway travel, and when the cylinders 70, 71 are extended the side segments 73 and 74 are tilted back down to a horizontal attitude suitable for mowing.

Central support wheels 75 and 76 are positioned behind and slightly out to the side of central segment 62 of the rear towed mower 22 with the wheels being mounted to axle 78. The axle in turn is mounted to support arms 79 and 80, with the support arms being pivotably mounted at their forward end portions to stanchions 81 and 82 of central segment 62. Hydraulic cylinders 83 and 84 extend between central frame element 72 in a downwardly sloped direction and each cylinder, 83, 84 is connected at its lower end to support arm 79 or 80. When the cylinders 83 and 84 are extended, the rear portion of the support frame 61 is raised away from the ground surface by the downward tilting of the support arms 79 and 80. Likewise, when the cylinders 83 and 84 are retracted, the support arms 79 and 80 tend to assume a horizontal attitude, thereby lowering the rear portion of the support frame 61. This permits the operator to selectively elevate the rear portion of the support frame of the central segment 62.

As illustrated in Figs. 2 and 3, the trailer tongue assembly 44 which connects the front self propelled mower to the rear towed mower 22 comprises an approximately U-shaped forward tongue member 86 having side legs 87 and 88, a base leg 89 and converging legs 90 and 91. The distal ends of the side legs 87 and 88 have laterally extending pins 93 and 94 rigidly mounted thereto, and the pins 93 and 94 are pivot about axis 97 and are releasibly received in sockets 95 connected to the frame of the front self propelled mower 21 immediately adjacent the axis of rotation of the rear powered wheels 24 and 25. The connection of the forward tongue member 86 to the frame of the front self-propelled mower immediately adjacent the

driving wheels 24 and 25 causes the weight of the rear towed mower 22 that is applied to the front self propelled mower 21 to be applied adjacent the wheels 24 and 25, thereby minimizing any tilting effect of the applied weight to the front mower. When the towed mower is to be detached from the front mower the pins 93 and 94 are withdrawn from the sockets 95.

The trailer tongue assembly 44 further includes a universal joint 96 (Fig. 3), which includes a double clevis connector 98 and a swivel assembly 99. Double clevis connector 98 includes a base plate 100 and forwardly extending vertical clevis leaves 101 and 102 and rearwardly extending horizontal clevis leaves 103 and 104. A socket 105 is mounted in a horizontal attitude to the rear portion of forward tongue member 86, and pivot pin 106 extends through socket 105 and aligned openings of forwardly extending vertical clevis leaves 101 and 102. This forms a horizontal pivot connection between the double clevis connector 98 and forward hitch member 86 about the horizontally extending axis 108.

Swivel assembly 99 includes a pair of spaced parallel support bars 110 and 111, with a vertical socket 112 mounted between the bars 110 and 111 at their forward end portions. The socket 112 is oriented vertically and is positioned between aligned openings of the rearwardly extending horizontal clevis leaves 103 and 104, and pivot pin 113 extends through the socket 112 and the openings of the clevis leaves 103 and 104, forming a vertical pivot axis 114.

The rear end portions of support bars 110 and 111 of the universal joint 96 are rigidly connected together by means of plates 116 and 117, and the plates 116 and 117 together with the support bars 110 and 111 surround lateral frame element 118, angle frame legs 119 and 120 and base leg 121. Pivot pin 122 extends through lateral frame element 118 and base leg 121, and through plates 116 and 117. The support bars 110 and 111 are spaced apart a distance greater than the thickness of the lateral frame element 118 and base leg 121, so that these elements can tilt with respect to each other around pivot pin 122. This construction permits the U-shaped forward tongue member 86 to rotate about the longitudinal axis 123 with respect to the support frame 61, with the longitudinal axis 123 extending along the length of the pivot pin 122. Thus, the universal joint 96 allows the rear towed mower 22 to have freedom of movement around the two axes 114 and 123 while the hitch pins 93 and 94 and their sockets 95 permit freedom of movement about axis 97 as the rear towed mower 22 is pulled by the front self propelled mower 21 over uneven terrain.

The height of the forward portion of the support frame 61 is adjustable by means of hydraulic cylinder 124. The end portions of cylinder 124 are connected to the stanchions 125a and 125b, with the retraction of the cylinder rod into the cylinder causing the stanchions 125a and 125b to move closer together and therefore move the trailer tongue 44 down toward the ground and thereby moving the forward portion of the support frame 61 downwardly, whereas when the cylinder rod of cylinder 124 is extended, the stanchions 125a and 125b are urged apart so as to tend to lift the trailer hitch away from the ground and to raise the forward portion of support frame 61.

With this arrangement, when cylinders 83, 84 and 124 are extended, the support frame 61 of the rear towed mower will be lifted away from the ground surface. Likewise, when the cylinders 83, 84 and 124 are retracted, the support frame 61 will be lowered toward the ground.

As illustrated in Figs. 1 and 2, side segments 63 and 64 of the support frame 61 of rear towed motor 22 are supported by caster wheels 126 and 127, with the caster wheels each having a support arm 128 extending from the stem 129 of each caster wheel laterally over to the decking of the side segment 63 or 64 of the rear towed motor 22. With this arrangement, the outer side portions of the side segments 63 and 64 of the support frame 61 are supported by the caster wheels 126 and 127, so that the side segments can undulate or pivot with respect to the central segment 62 in bat-wing fashion.

Each side segment 63 and 64 includes a hydraulic motor 130 that drives a sheave 131, with the sheave powering the driving belt 132. The driving belt 132 extends about the cutter blade sheaves 134 and 134, with one or more spring urged idler sheaves 136 and 137 applying tension to the driving belt 132. The cutter sheaves 134 and 135 each are mounted to a mandrel that is connected to a cutting blade 138a and 138b, respectively, beneath the decking of the side segments 63 and 64, so that the driving belt 132 rotates the cutting blades at high angular velocities so as to cause the cutting blades to cut the grass or other vegetation immediately beneath the side segments 63 and 64.

The embodiment of the towed cutter illustrated in Figs. 1-3 includes two rotary cutting blades 138a and 138b positioned in each side segment 63 and 64 of the support frame 61 of the rear towed mower 22, with the cutting blades sloped rearwardly on opposite sides of the mower assembly so that they slightly overlap with respect to each other as the mower assembly moves in a forward direction as indicated by direction arrow 140. The overlapping cutting blades therefore cut a continuous swath in the grass as indicated by dash lines 141 and 142, and 134, 144, respectively. The swath lines 142 and 143 are positioned so as to overlap the swath cut by the front mower 21, as indicated by swath lines 54 and 55.

As illustrated in Fig. 1, the forward edge portions or skirts 146 of the decking of the cutter unit 30 of the front mower 21 curve about the paths of the outer end portions of the cutting blades 53a and 53b. The front skirts 148 of the side segments 63 and 64 of the rear towed mower 22 are sloped rearwardly and outwardly. This slanted arrangement provides a fender effect for the towed mower, in that if the fender 148 of either side segment 63 or 64 should engage an obstruction the fender tends to either push the obstruction out of the path of the towed motor, or if the obstruction is immovable, the fender engages the obstruction and urges the towed mower laterally and guides the towed mower around the obstruction. The towed mower tends to skew laterally about its trailer tongue vertical axis 114 when encountering the immovable object, and the relatively light weight of the towed mower, together with the caster wheels 126 and 127, tend to permit this skewing movement. The wheels 75 and 76 tend to skid laterally during this movement.

Bumpers 149 are mounted to the decking to provide additional protection for the front skirts 148 when the side segments are raised to upright positions. Likewise, bumpers 77 extend from the support arms 79 in front of wheels 76 to protect the wheels from obstruction. In the preferred embodiment, the outside width of the towed mower with the vertically hinged side frame segments pivoted up to vertical nonoperating positions is less than the outside width of the front mower so that the towed mower will avoid collision with objects trimmed around with the front mower.

Fig. 4 illustrates another embodiment of the towed mower 150, in which three rotary cutting blades, 151, 152 and 153 are mounted in each side segment 155, 156. The blades 151-153 in each side segment are angled rearwardly in bat-wing fashion so that the blades slightly overlap one another in the forward direction of movement to avoid streaks of uncut grass being left in the swath of cut grass.

Fig. 5 illustrates another embodiment 160 of the towed mower, whereby a single cutting blade 161 is mounted in each side segment 162, 163 of the towed mower.

Fig. 6 illustrates yet another embodiment of the towed mower whereby the towed mower 170 has three cutting blades 171, 172 and 173 arranged in triangular relationship in each side segment 175, 176.

Fig. 7 discloses another embodiment of the towed mower 180 which includes side segments 181 and 182 constructed in a manner similar to that illustrated in Figs. 1-3, but a central segment 183 that has its central support wheels 185 and 186 located beneath the central segment of the support frame. The location of the wheels 185 and 186 in this manner tends to cause more of the weight of the towed motor to be supported on its wheels rather than on its trailer hitch.

While the prior art towed mowers require the operator to look back to view the operation of the towed mowers when trimming about obstacles, this invention utilizes the front mower for trimming. One or both of the two side segments 63 and 64 are raised to their vertical nonfunctioning positions where they are located inside the swath cut by the front cutter and are out of the way of the obstacle being trimmed around. This allows the operator to cut with the front mower adjacent an obstacle without having to worry about a rear mower empacting the obstacle and permits the operator to observe the trimming operation while still looking in the direction of movement of the mower.

As illustrated in Fig. 8, the trailer hitch 190 can be substituted for the trailer hitch of Fig. 3 if the forward hitch member 191 is rigidly, not pivotally, attached to the front mower. The ball 192 is mounted to the forward hitch member 191, and the socket 193 is mounted to the support frame 194 of the towed mower. The socket 193 simply receives and rests on the ball 192 in the conventional trailer hitch manner.

As illustrated in Fig. 9, another trailer hitch connection can be formed between the front mower and the towed mower, by mounting a caster wheel 198 to the forward portion of the support frame 199 of the towed mower so that the front portion of the towed mower is supported by the caster wheel 198 and the towed mower remains in a fixed attitude and is self-supporting. The U-shaped forward hitch member 200 has the distal ends of its arms pivotally connected in clevises 201 and 202, and a socket 203 is mounted to the forward hitch member 200 so as to receive and rest upon the ball 204 of the towed cutter.

Fig. 10 illustrates another trailer hitch construction which includes a caster wheel 206 that supports the forward portion of the towed mower, a rigid forward hitch member 207 is mounted to the rear of the front mower and supports the ball 208, and the rear hitch member 209 is pivotally connected in clevises 210 and 211 to the central segment 212 of the towed mower. The socket 214 is mounted to rear hitch member 209 and receives ball 208.

Fig. 11 illustrates another trailer hitch construction which includes a caster wheel 220 mounted to tongue 221 that supports the forward portion of the tower mower, a U-shaped forward hitch member 222 pivotally connected in clevises 223 and 224 about horizontal axis 225 to the front mower (not shown) and universal joint 226 extending between the front mower and the towed mower. The universal joint includes first connector 228 which extends through U-shaped hitch member 222 and is connected thereto by a washer 229 and bolt 230 so that the first connector is pivotable about longitudinal axis 131. The rear end portion of first connector 228 comprises a clevis 232. The forward end portion of tongue 221 also comprises

a clevis 234, and intermediate link 235 is connected at its ends to the clevises. The clevises and their pivot pins 236 and 237 are oriented at 90° angles with respect to each other and link 235 is pivotable about vertical axis 240 and horizontal axis 241.

Fig. 12 is a schematic plan view of the mower and shows how the mower assembly 20 performs when moving through a right hand turn. The rotary cutters of the cutter unit 30 of the front mower 21 cut a swath as indicated by the right and left swath cuts 54 and 55. In the meantime, the towed cutter 22 cuts swaths that straddle and slightly overlap the swath 54, 55, as indicated by the swath cut lines 141, 142 and 143, 144. The distance (H_1) of the vertical axis 114 of the trailer tongue 44 to the rear driving wheels 24 and 25 of the front mower as compared to the distance (H_2) from the vertical axis 114 of the trailer tongue to the central support wheels 75, 76 is constructed so that the towed mower always cuts its swath in straddling, overlapped relationship with the swath cut by the front mower even when the mower assembly moves through a sharp turn in which the front mower is angled up to 60° with respect to the towed mower. These distances are indicated on Fig. 13 by the designations H_1 and H_2.

The following formulas show the dimensional relationship between the front mower and towed mower necessary to eliminate streaking in which:

H_1 + distance between vertical axis 114 of tongue to axis of rotation of rear driving wheels of front mower 21

H_2 = distance between vertical axis 114 of tongue to axis of rotation of central support wheels of rear towed cutter 22

WB = Wheelbase = $H_1 + H_2$

AA = Articulation Angle

$H_2 = WB - H_1$

$$H_1 = H_1 \cos AA + WB - \left(\frac{R\not{\phi}}{(\tan (90°-AA))}\right) \cos AA$$

$$H_1 = H_1 \cos AA + WB - [R\phi\phi + H_2 \tan AA] [\cos AA \times \cos (90^\circ - AA)]$$

Where Ro and Roo are such that $R_3 - R_1 = R_4 - R_2$

$$R\phi = \frac{(H_1 \cos AA + H_2)}{(\cos AA)} \tan (90^\circ - AA)$$

$$H_2 = WB - H_1$$

$$R\phi = \frac{(H_1 \cos AA + WB - H_1)}{(\cos AA)} \tan (90^\circ - AA)$$

$$\frac{R\phi}{\tan (90^\circ - AA)} = \frac{H_1 \cos AA + WB - H_1}{\cos AA}$$

$$\left[\frac{R\phi}{[\tan (90^\circ - AA)]}\right] \times \cos AA = H_1 \cos AA + WB - H_1$$

$$H_1 = H_1 \cos AA + WB - \left[\frac{R\phi}{[\tan (90^\circ - AA)]}\right] \cos AA$$

$$R\phi\phi = \frac{H_1 \cos AA + H_2}{\cos AA \times \cos (90^\circ - AA)} - H_2 \tan AA$$

$H_2 = WB - H_1$ where WB = wheelbase

$$R\phi\phi = \frac{H_1 \cos AA + WB - H_1}{\cos AA \times \cos (90^\circ - AA)} - H_2 \tan AA$$

$$R\phi\phi + H_2 \tan AA = \frac{H_1 \cos AA + WB - H_1}{\cos AA \times \cos (90^\circ - AA)}$$

$$[R\phi\phi + H_2 \tan AA] [\cos AA \times \cos (90^\circ - AA)] = H_1 \cos AA + WB - H_1$$

$H_1 + [R\phi\phi + H_2 \tan AA] [\cos AA \times \cos (90^\circ - AA)] = H_1 \cos AA + WB$

$H_1 = H_1$ ocs AA + WB -[Røø + H_2 tan AA] [cos AA x cos (90° - AA)]

The formula describes in mathematic terms the relationship of the dimensions of the front and rear mower that must be maintained to accomplished tracking where the rear swaths will coincide with the front swath. The actual relationship between these components can be deviated from so long as the designed

overlap in cutting swaths are adequate to compensate for these deviations. The cutting swaths of the rear cutters must always overlap the cutting swath of the front cutter so as to compensate for errors in the rear mower tracking behind the front mower. For example, when the mower assembly is operating on a sloped surface the towed mower tends to skid sideways down the sloped surface. Also when the mower assembly is driven at a fast pace through a turn the rear mower is urged by centrifugal force outwardly of the turn. Also there may be intentional and unintentional manufacturing deviations from the formula which cause the towed mower to incorrectly track behind the front mower.

The invention has been disclosed with the internal combustion engine 31 and pumps 32, 33 and 34 serving as power means for operating the hydraulic motor 45, power steering cylinders, hydraulic cylinders 70, 71, 83, 84 and 124. Additional pumps can be mounted to the cluster of pumps 32-34, if desired so as to provide more sources of power, as may be desired. The hydraulic conduits which extend from the pumps to the motors and cylinders have not been shown to simplify the drawings. However, it will be understood by those skilled in the art that other power units can be utilized, if desired. For example, a separate internal combustion engine can be mounted to the towed mower unit and can provide the power for the cutters of the side segments. Further, when the towed mower is used behind the type of power unit that includes a mechanical power take-off system, a conventional gearbox and shafts extending from the gearbox out to the cutting blades of each side frame segment can be used.

Further, the front mower can comprise the type of mower that includes a support frame with one or more cutters suspended from the frame.

The cutters illustrated and described herein comprise rotary cutting blades; however, other type cutters can be used, if desired, such as reel, sickle and flail cutters.

It should be understood that the embodiments of the invention disclosed herein illustrate principles of the invention in a preferred form. Other modifications, additions and deletions may be made thereto without departure from the spirit and scope of the invention as set forth in the following claims. .

Claims

1. In combination a self propelled front mower and a towed rear mower for cutting grass and other vegetation, said front mower comprising rear driving wheels engaging the ground surface for moving the front mower in a forward direction and front cutter means arranged for cutting a swath in the grass and like vegetation beneath the front mower, said rear mower including a support frame extending laterally on opposite sides of the swath to be cut by said front mower, wheel means supporting said support frame on the ground surface, rear cutters mounted to said support frame and spaced from each other on opposite sides of the swath cut by said front mower a distance to cut swaths in the grass and the like beneath the rear mower that partially overlap the swath cut by said front mower, connecting means connecting said rear mower to said front mower in trailer fashion, and power means for driving said driving wheels, said front cutter and said rear grass cutters,

2. The combination of claim 1 and wherein said power means comprises an internal combustion engine mounted to said front mower in a position in front of said driving wheels, and wherein said front cutter means comprises at least one rotary cutter positioned in front of said internal combustion engine.

3. The combination of claim 2 and wherein said front mower comprises a power unit with said internal combustion engine and said driving wheels mounted on said power unit and a cutter deck positioned in front of said power unit and said rotary cutter mounted on said cutter deck, and pivot connecting means connecting together said power unit and said cutter deck about an axis extending longitudinally with respect to the forward direction of movement of said front mower.

4. The combination of claim 1 and wherein the support frame of said rear mower comprises three laterally extending segments including a central segment and side segments positioned on opposite sides of said central segment, said side segments each movably connected to said central segment and with each segment including wheels or the like for supporting the rear portions of the segments from the ground surface, said connecting means being mounted to said central segment, and said rear cutters being carried by said side segments.

5. The combination of claim 1 and wherein said connecting means pivotally connects said rear mower to said front mower adjacent said rear driving wheels and applies a portion of the weight of the rear mower to the front mower at the rear driving wheels of the front mower.

8. The combination of claim 4 and wherein said connecting means pivotally connects the forward portion of the central segment of said rear mower to said front mower adjacent the rear driving wheels of said front mower and applies a portion of the weight of said rear mower to the front mower at the rear driving wheels of the front mower.

7. The combination of claim 4 and wherein the central segment of said rear mower includes a wheel or the like for supporting the forward portions of the segments from the ground surface.

8. The combination of claim 4 and wherein said connecting means comprises an approximately U-shaped forward hitch member connected at the free ends of its arms to the front mower at said rear driving wheels, and a universal joint connected between said forward hitch member and the central segment of said rear mower.

9. The combination of claim 8 and wherein said forward hitch member is pivotally connected to the front mower at said rear driving wheels, and further including means for adjusting the height of the universal joint from the ground surface.

10. The combination of claim 4 and further including means for adjusting the height of said central segment from the ground surface.

11. In combination, a self propelled mower and a towed mower for cutting grass and other vegetation, said self propelled mower comprising a power unit including an internal combustion engine, driving wheels driven by said engine with said driving wheels engaging the ground surface and for moving the self propelled mower in a forward direction, and a front cutter unit including cutters driven by said power unit positioned for cutting a swath of grass or the like as the mower moves in a forward direction over the grass, said front cutter unit including a wheel means for supporting said front cutter unit from the ground surface, pivot connecting means for connecting together said power unit and said front cutter unit about an axis extending longitudinally with respect to said power unit and said front cutter unit, said towed mower comprising a frame extending laterally on opposite sides of said axis, wheel means mounted to said frame and supporting said frame from the ground surface, hitch means at the forward portion of said frame and connecting said frame to the power unit of said mower in trailer fashion, and cutters mounted to said frame and spaced from each other on opposite sides of said axis a distance for cutting swaths of grass or the like that partially overlap the swath cut by the front cutter unit.

12. The combination of claim 11 and wherein said hitch means comprises a trailer hitch.

13. The combination of claim 11 and further including pump means mounted on said self propelled mower in driven relationship with respect to said internal combustion engine and hydraulic motor means mounted on said towed mower driven by said pump means and in driving connection with the cutters of said towed mower.

14. The combination of claim 11 and wherein the frame of said towed mower is formed in three laterally extending segments including a central segment and side segments on opposite sides of said central segment, connecting means pivotally connecting said side segments to said central segment and with each segment including wheels or the like for supporting the segments from the ground surface, said hitch means being mounted to the central segment, and said cutters carried by the side segments.

15. A towed mower for connection to a self propelled front mower of the type including driven wheels and a cutter positioned for cutting a swath in the grass or the like vegetation as the front mower moves in a forward direction, said towed mower comprising a frame formed in three segments with a central segment and side segments positioned on opposite lateral sides of said central segment, means pivotably connecting said side segments to said central segment about longitudinal axes, a trailer hitch mounted to the forward portion of said central segment and wheel means mounted to all three segments for supporting the segments from the ground surface, cutters carried by each of said side segments, motor means carried by said towed mower and arranged to operate the cutters, said cutters being positioned apart a distance so as to cut swaths in the grass and the like that partially overlap the swath cut by the cutter of the self propelled mower.

16. The towed cutting unit of claim 15 and further including hydraulic means for tilting said side segments with respect to said central segment whereby the said segments are lifted away from the ground surface and the central segment supports the side segments from the ground surface.

17. The towed cutting unit of claim 15 and wherein said power means comprises a hydraulic motor mounted to each side segment and hydraulic transfer conduits connected to each said hydraulic motor and for connection to a source of fluid pressure.

18. In combination, a self propelled front mower and a detachable rear towed mower, said front mower comprising a power unit with driving wheels engaging the ground surface and for moving the front mower in a forward direction, and a front cutter positioned in front of the driving wheels of said power unit for cutting a swath of grass or the like as the front mower moves in a forward direction,

said towed mower comprising a frame formed in three segments extending laterally with respect to each other and with respect to the direction of forward movement of said mower including a central frame segment and side frame segments positioned on opposite sides of said central frame segment, said central frame segment being aligned with said front cutter along the direction of forward movement of said front mower so as to follow in the swath cut by said front cutter,

a connector means connecting the central frame segment of said towed mower to said front mower, and wheels mounted to said central frame segment for supporting said central frame segment from the ground surface,

pivot connectors mounted between each of said side frame segments and said central frame segment for partially supporting said side frame segments from said central frame segment and to permit said side frame segments to pivot up and down with respect to said central frame segment,

at least one wheel means mounted to each of said side frame segments for supporting each side frame segment from the ground surface,

cutters mounted to each side frame segment for cutting swaths in the grass and the like that straddle the swath cut by said front cutter, and

means mounted to said frame for transmitting power to the cutters of said side frame segments.

19. The combination of claim 18 and wherein at least one wheel means mounted to each of said slide frame segments comprises a caster wheel normally in engagement with the ground surface behind each said side frame segment, and wherein the wheels mounted to said central frame segment comprise at least two wheels mounted beneath said central frame segment.

20. The combination of claim 18 and wherein said at least one wheel means mounted to each of said side frame segments comprise a caster wheel normally in engagement with the ground surface behind said frame.

21. The combination of claim 18 and wherein said wheels mounted to said central frame segment comprise at least two wheels mounted beneath said central frame segment between said side frame segments.

22. The combination of claim 18 and wherein said wheels mounted to said central frame segment comprise at least two wheels with each wheel mounted laterally out to one side and to the rear of said central frame segment.

23. The combination of claim 18 and wherein said wheels mounted to said central frame segment are positioned between said side frame segments.

24. The combination of claim 18 and wherein central frame segment further includes at its forward end portion a ground engaging support means so that said towed mower is self supporting in a proper cutting attitude, and wherein said trailer hitch is pivotably mounted to said central frame segment about a laterally extending axis.

25. The combination of claim 24 and wherein said ground engaging support means comprises a caster wheel.

26. The combination of claim 18 and wherein said trailer hitch is pivotably mounted to said power unit about a laterally extending axis.

27. The combination of claim 18 and further including pivot connecting means connecting together said power unit and said front cutter unit about an axis extending longitudinally with respect to said power unit and said front cutter unit.

28. In combination, a self propelled front mower and a rear towed mower, said front mower comprising a power unit with driving wheels engaging the ground surface and for moving the front mower in a forward direction and a front cutter with wheels engaging the ground surface, said front cutter cutter positioned in front of said power unit and including blades for cutting a swath of grass or the like as the mower moves in a forward direction, a tilt connector mounted to said power unit and to said front cutter and arranged to permit the front cutter to tilt with respect to said power unit about an axis extending in the forward direction of movement of the power unit, said towed mower comprising first and second side cutters with cutting blades positioned in overlapping straddling relationship with respect to the swath cut by the cutting blades of said front cutter when the mower and towed mower move in a forward direction, wheel means mounted to said towed mower for movably supporting the towed mower on the ground surface, a hitch assembly extending forwardly from said towed cutter and connected to said power unit, said hitch assembly including a universal joint that permits pivoting of said towed mower about upright, lateral and longitudinal axes with respect to said front mower.

29. The combination of claim 28 and wherein the dimensions between the upright axis and the driving wheels of said front mower and between the upright axis and the wheel means of the towed motor and the placement of the cutting blades of said front cutter and the cutting blades of said side cutters are selected to cause the rear cutters to straddle and overlap the swath cut by the front cutter as the front and rear mower move through a turn.

30. The combination of claim 29 and wherein the structure of the front and rear mowers are formed in accordance with:

H_1 = distance between vertical axis 114 of tongue to axis of rotation of rear driving wheels of front mower 21

H_2 = distance between vertical axis 114 of tongue to axis of rotation of central support wheels of rear towed cutter 22

WB = Wheelbase = $H_1 + H_2$

AA = Articulartion Angle

$H_2 = WB - H_1$

$$H_1 = H_1 \cos AA + WB - \left(\frac{R\phi}{(\tan (90°-AA))}\right) \cos AA$$

$H_1 = H_1 \cos AA + WB - [R\phi\phi + H_2 \tan AA] [\cos AA \times \cos (90° - AA)]$ Where Rø and Røø are such that $R_3 - R_1 = R_4 - R_2$

$$R\phi = \frac{(H_1 \cos AA + H_2)}{(\cos AA)} \tan (90° - AA)$$

$$H_2 = WB - H_1$$

$$R\phi = \frac{(H_1 \cos AA + WB - H_1) \tan (90^\circ - AA)}{(\cos AA)}$$

$$\frac{R\phi}{\tan (90^\circ - AA)} = \frac{H_1 \cos AA + WB - H_1}{\cos AA}$$

$$\left[\frac{R\phi}{[\tan (90^\circ - AA)]}\right] \times \cos AA = H_1 \cos AA + WB - H_1$$

$$H_1 = H_1 \cos AA + WB - \left[\frac{R\phi}{[\tan (90^\circ - AA)]}\right] \cos AA$$

$$R\phi\phi = \frac{H_1 \cos AA + H_2}{\cos AA \times \cos (90^\circ - AA)} - H_2 \tan AA$$

$$H_2 = WB - H_1 \qquad \text{where } WB = \text{wheelbase}$$

$$R\phi\phi = \frac{H_1 \cos AA + WB - H_1}{\cos AA \times \cos (90^\circ - AA)} - H_2 \tan AA$$

$$R\phi\phi + H_2 \tan AA = \frac{H_1 \cos AA + WB - H_1}{\cos AA \times \cos (90^\circ - AA)}$$

$$[R\phi\phi + H_2 \tan AA] [\cos AA \times \cos (90^\circ - AA)] = H_1 \cos AA + WB - H_1$$

$$H_1 + [R\phi\phi + H_2 \tan AA] [\cos AA \times \cos (90^\circ - AA)] = H_1 \cos AA + WB$$

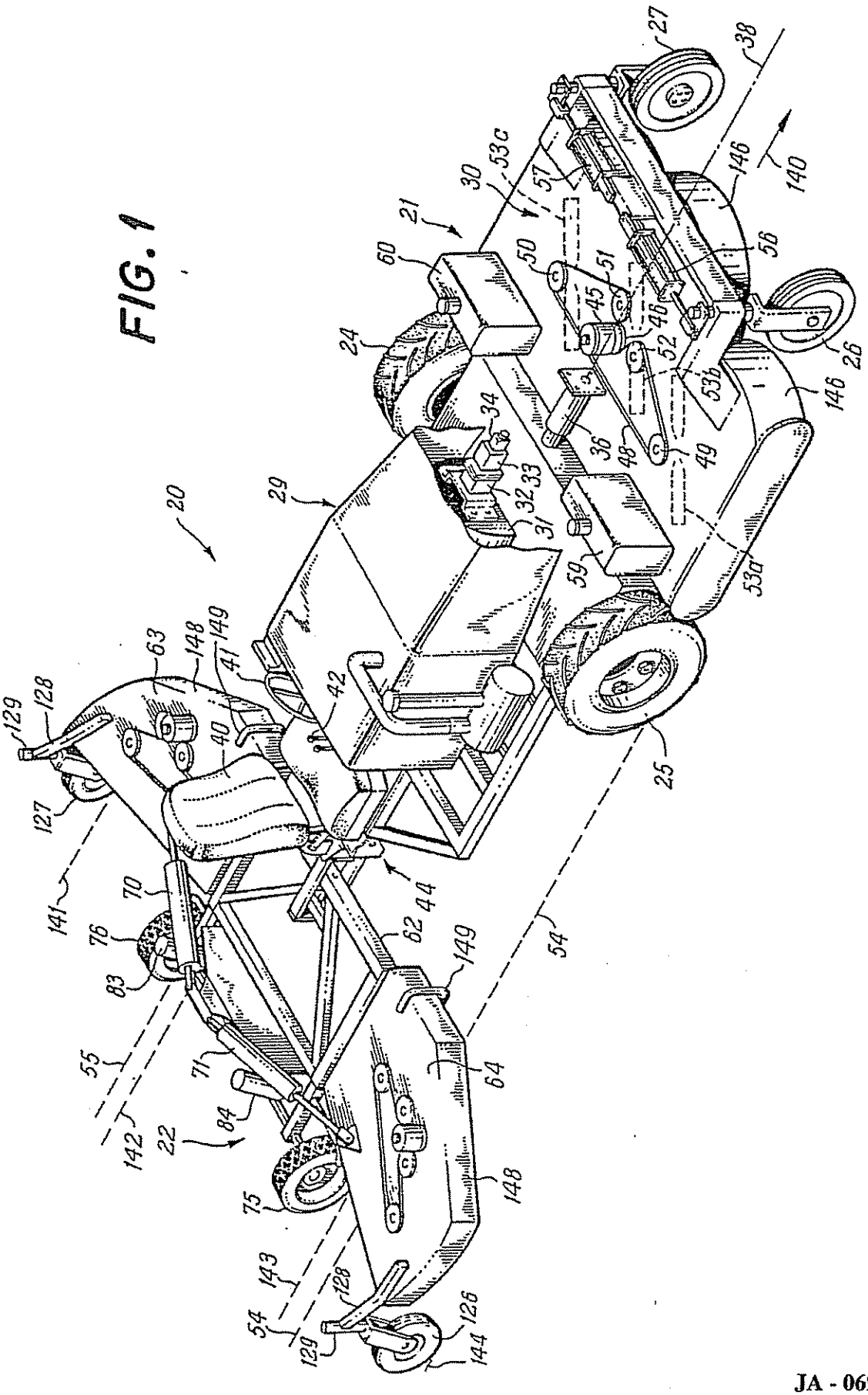
$$H_1 = H_1 \cos AA + WB - [R\phi\phi + H_2 \tan AA] [\cos AA \times \cos (90^\circ - AA)]$$

31. In combination a self propelled front mower and a towed rear mower, said front mower comprising rear driving wheels engaging the ground surface for moving the front mower in a forward direction and front cutter means arranged for cutting a swath in the grass or like vegetation beneath the front mower, said rear mower including a support frame extending laterally on opposite sides of the swath to be cut by said front mower, rear cutters mounted to said support frame and spaced from each other on opposite sides of the swath cut by said front mower on a distance to cut swaths in the grass beneath the rear mower that partially

overlap the swath cut by said front mower, means connecting said rear mower to said front mower in trailer fashion, and power means for driving said driving wheels, said front cutter and said rear cutters pivotably mounting said rear cutters to said towed mower whereby the rear cutters can be raised to upright inoperative positions, the width of said towed mower being less than the width of said front mower when said rear cutters are raised to their upright inoperative positions.

32. In combination, a self propelled front mower and a rear towed mower for cutting grass and other vegetation, said front mower comprising a power unit with driving wheels engaging the ground surface and for moving the front mower in a forward direction and a front cutter with wheels engaging the ground surface, said front cutter including blades for cutting a swath of grass or the like as the mower moves in a forward direction, said towed mower comprising first and second side cutters with cutting blades positioned in overlapping straddling relationship with respect to the swath cut by the cutting blades of said front cutter when the mower and towed mower move in a forward direction, wheel means mounted to said towed mower for movably supporting towed mower on the ground surface, a hitch assembly extending forwardly from said towed cutter and connected to said power unit, said hitch assembly including a universal joint that permits pivoting of said towed mower about upright, lateral and longitudinal axes with respect to said front mower, the driving dimensions between the upright axis and the driving wheels of said front mower and between the upright axis and the wheel means of the towed mower and the placement of the cutting blades of said front cutter and the cutting blades of said side cutters are selected to cause the rear cutters to straddle and overlap the swath cut by the front cutter as the front and rear mower move through a turn.

FIG. 1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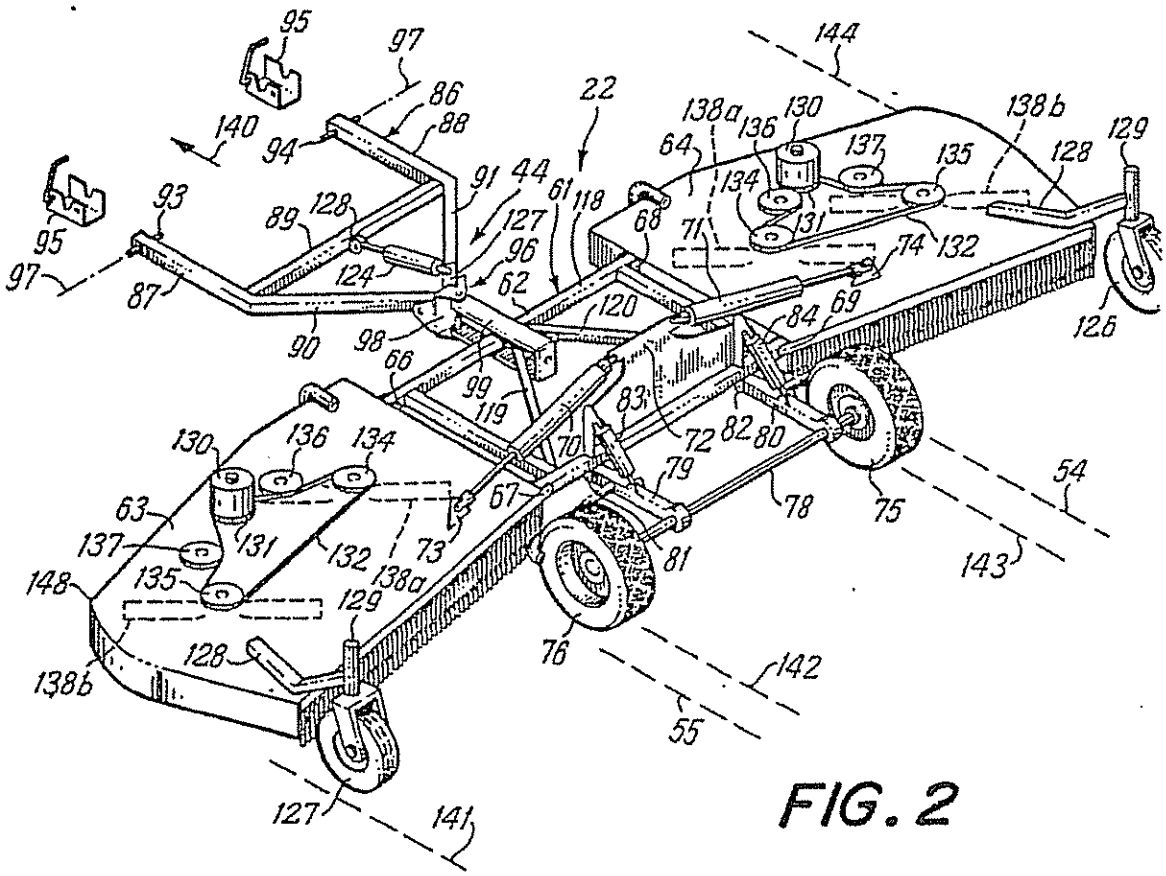
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FIG. 2

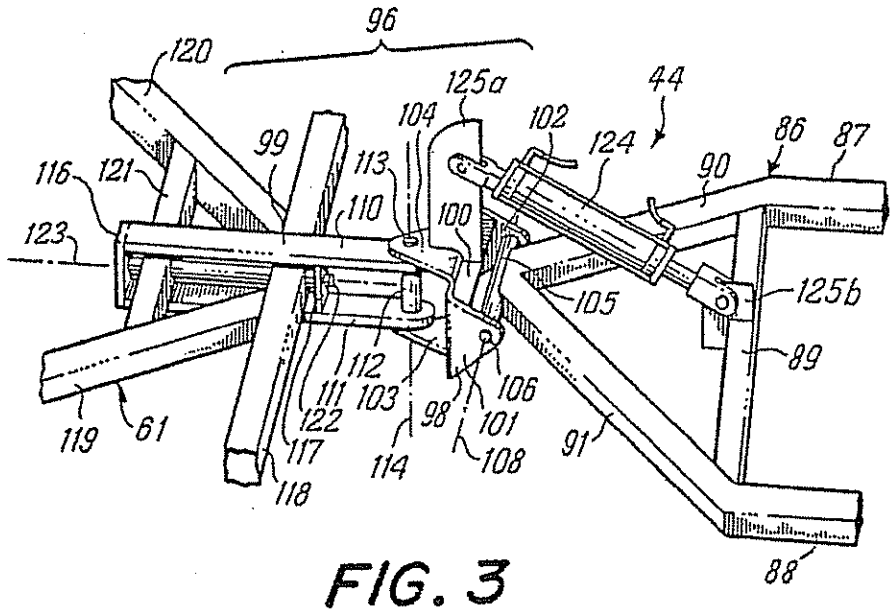
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FIG. 3